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ABSTRACT

Despite recent science education reform efforts, researchers continue to report the under-representation of females in science professions and coursework. As concerned educators, organizations, and institutions consider ways to facilitate female participation in science, it is important to examine what serves as door-openers and gate-keepers to their science practice and how an inclusionary practice of science and science discourse can be developed. This study examines the aspects of a science education Web course that engaged female elementary teachers in science inquiry and talk. It particularly explores the characteristics of science discourse that support women's participation, the instructional practices used to facilitate (or not) women's science activity and discourse, and the ways in which the use of computer technology leads to the inclusion or exclusion of women's science participation. (Contains 22 references.) (Author/CCM)

Engaging Women in Inquiry and Discourse:

The Pedagogy of an Elementary Science Education Web Course

by

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Objectives

Despite recent science education reform efforts (AAAS, 1993; NRC, 1996), researchers continue to report the under-representation of females in science professions and coursework (NSF, 1996). As concerned educators, organizations, and institutions consider ways to facilitate females' legitimate participation in science, it is important to examine what serves as door-openers and gatekeepers to their science practice and how an inclusionary practice of science and science discourse can be developed.

Theoretical Framework

Introduction

Recent discussions about how persons join communities of practice--such as science--suggest that through engagement in social practice with experts and novices, individuals (a) acquire valuable resources, (b) learn the knowledge, skills, and ways of the community; and (c) interact and contribute within the profession and are seen as valued members (Delamont, 1989; Lave & Wenger, 1991). Full participation in a community of practice results not only in knowledge acquisition, but also in "*becoming* part of the community" and the development of an "increasing sense of identity as a master practitioner" (Lave & Wenger, 1991, p. 111). However, the structure and power relations within a community can open, limit, or close access to legitimate participation to individuals or groups (Lave & Wenger, 1991). If access to participation is blocked, then individuals can be excluded and/or marginalized.

Educational researchers have illuminated many factors that contribute to the construction of boundaries within the science community and the subsequent insider/participant status for some groups and peripheral/outsider status for others including: 1) the exclusive curricula that ignore the approaches, contributions, and achievements of females, 2) the biased content of research agendas and the privileging of scientific approaches that are abstract, separate, and impersonal, and 3) hegemonic social and institutional structures and practices (AAUW, 1992; Harding, 1991)).

Furthermore, issues of discourse and learner autonomy in inquiry, play an important role in females' legitimate participation in science activity.

Discourse

Becoming a legitimate participant in the science community entails the ability to explain and justify one's understandings, the questions that guide one's inquiries, the methods that one employs, and the conclusions that one draws (NRC, 1996). Key to legitimacy is the ability to talk science in accordance with beliefs, norms, and values unique to that practice. Yet, some aspects of traditionally accepted scientific discourse can be exclusive and limiting.

First of all, the competitive and aggressive nature of scientific discourse can marginalize or exclude some. In a study of women working in the sciences, they described the discourse of the science community as not about sharing ideas, knowledge, and skills and learning from that, but based in competition and aggression where individuals must continuously prove themselves and establish a superior and dominant position (Davis, 1996). For example, participants in this study reported that individuals in science contexts often made statements and posed questions, not for the purpose of sharing information or for finding out what someone else knows and learning from that, but instead, to posture—to let others know that only they know the answer or that the information that is shared is something that is important to his/her research and that it should be acknowledged. Informants described the discourse in science as aggressive--in their words: speaking authoritatively, arguing "like cats and dogs," "being criticized...[and] judged unfairly," humiliating..." "a constant... chopping away," "yelling at you," being "on the hot seat," and arguing to find "truth to the death." One participant described "the styles of the ways in which people relate information [as] a bit repugnant." The interactions in science settings were described as intense--where one needs to continually prove oneself.

To compound this, science values critical thinking and so students of science are asked to develop reasoning and critical response skills (NRC, 1996). They must be critical of theirs and others' thinking and be ready to hear such critique as well (AAAS, 1993). Science contexts such as these may be silencing for some as voicing one's speculations involves an element of risk.

Speaking freely in classroom settings can be difficult especially when there is disagreement. The Benchmarks state, "Because youngsters want to be liked, this notion that one can disagree with friends and still be friends is not easy to accept (and may not be true in the short run)...(AAAS, 1993, p. 15). Also, due to their socialization, females may perceive criticizing others or being criticized as being disruptive and as challenging their relationships with others (Gilligan, 1991). Tannen (1998) notes that

> limiting critical response to critique means not doing the other kinds of critical thinking that could be helpful: looking for new insights, new perspectives, new ways of thinking, new knowledge. Critiquing relieves you of the responsibility of doing integrative thinking. It also has the advantage of making critics feel smart...but the disadvantage of making them less likely to learn from [others'] work. (pp. 273-274)

Interestingly enough, Davis (1996) noted that the kind of discourse that took place in the context of the all-female science setting she studied provided a contrast to the discourse the women described in their daily work and school environments. The nature of the talk within their group was based on the acquisition and sharing of information. Within the group, the members would question others for information; share personal knowledge and experiences; make suggestions; tell stories; describe situations and events; give examples; advise; and report on activities and practices that individuals had tried out.

Research on discourse practices provides us with several ways to look at this issue. First of all, in her research, Tannen (1994) contends that individuals from different gender, ethnic, racial, geographic backgrounds engage in different conversational rituals. Based on her research of white, middle class men and women, she reports that, in general, men often use "banter, joking, teasing, and playful put-downs" and expend effort "to avoid the one-down position" (p. 23). Men consider questioning as a sign of being less capable. In general, men are more comfortable touting their successes. She notes that where work settings historically have had men in positions of power, such as science, an established male-style interaction is often the norm.

In contrast, women are more likely to ask questions when they are seeking information. They often seek "ways of maintaining equality, taking into account the effect of the exchange on the other person, and expending effort to downplay the speakers' authority so they can get the job down without flexing their muscles" (p. 23). Studies indicate that, among women, "discourse patterns reflect active listening, building on the utterances of others, collaboration rather than competition, flexible leadership rather than the strong dominance patterns found in all-male groups" (Thorne, Kramarae, and Henley, 1983, p. 18).

Importantly, as such discourse practices are reproduced within the science community, so is the oppressive, hierarchical structure that has long been in place in society and work settings such as science. In the same way that the sexual division of labor consistently shows a pattern of male dominance which thwarts any considerations that it occurs "naturally," the sexual division of labor in discourse is not a just a result of cultural difference but a reproduction of a male hegemony in society (Uchida, 1998). The set of cultural rules that dictate how males and females should behave and talk are intricately intertwined with the positions in which men and women are placed in the hierarchies of society, including the science community. The strength of male domination demands a system of talk that "prioritizes…men's words over the words of women" (Lewis, 1993, p. 21), and such perceived status differences in science contexts can lead to silencing for women and other groups. As it is, males often dominate the talk and activity in science settings (Sadker, Sadker, & Klein, 1991).

Learner Autonomy in Inquiry

Hildebrand (1998) describes scientific discourse as positivist, masculine, hegemonic, and reflective of learning that is "received and reproductive" rather than "authentic and constructed" (p. 349). She points to the tacit assumption "that access to power in science will occur only if all students are taught to write as the scientific elite write" (p. 350). However, she contends that

> Only a limited access to power can be envisaged from this standpoint....[T]o uncritically perpetuate writing practices that are implicitly underpinned by an ideology

> that links science with power and masculinity is to choose to teach in ways that generate privilege for *some* students. (p. 351) (Italics in the original.)

As individuals see only the experiences, thoughts, and ideas of others as valued, then it may be difficult to confidently see a legitimate place for themselves within a community. In contrast, if individuals' meaningful inquiry, activity, and talk become part of the process of solving problems, answering questions, and determining practice, then they are more likely to develop an identity of legitimate participant.

Researchers working from feminist perspectives have proposed inclusive pedagogical approaches (Davis, 1999; Eisenhart & Finkel, 1999; Hildebrand, 1998; Rouchoudary, Tippins, & Nichols, 1995) that provide students with opportunities to: 1) use and integrate the knowledge, skills, and tools of science and technology as part of relevant inquiry; 2) talk about their science activity in meaningful ways; and 3) engage in learning that provides multiple and diverse ways of talking and thinking. Previous research (Davis, 1996, 1999a, 1999b, Davis & Falba, under review) indicates that within multiple contexts, including the everyday school environment, students must be able to make decisions about their science based on their own insights and judgments; to ask meaningful questions and design their own explorations and methods of communication; implement goals, activities, and experiences; and reflect on the results of their investigations and the effectiveness of their choices. In this way, discourse comes in many forms--not only should it be considered as written and oral expression, but also as "having say" as equal participants within a community of practice.

This study examines the aspects of a science education web course that engaged female elementary teachers in science inquiry and talk. In particular, through this study, I explore 1) the characteristics of science discourse that support women's participation; 2) the instructional practices used to facilitate (or not) women's science activity and discourse; and 3) the ways the use of computer technology lead to the inclusion or exclusion of women's science participation.

Methods

The Course

The Science K-6: Investigating Classrooms Web Course was co-created by the author and a professor emeritus of the University of Massachusetts at Amherst and the WGBH Educational Foundation in Boston. The 14-week online course was designed for the professional development of teachers in science. Based on the Science K-6: Investigating Classrooms video series and funded by the National Science Foundation, the course aimed to foster meaningful discussions about the nature and practice of elementary science education. As teachers engaged in the activities of this course, the instructors sought to provide the participants with a context for legitimate science activity and participation. With this in mind, the instructors of the course aimed to: (1) help teachers identify the elements of inquiry teaching and learning and implement them in their science classrooms, (2) introduce teachers to the nature of science by involving them in the scientific inquiry process, (3) explore with teachers the topics of constructivism, conceptual learning and meaning-making, equity, questioning, group work, student ideas, and assessment as they relate to learning in the inquiry-based science classroom, (4) encourage teachers to reflect on their own science teaching, the culture of their classroom, and the outside influences that affected their teaching, (5) guide teachers in carrying out a piece of original research about teaching and learning in their classrooms on a topic of their choice, (6) help teachers become familiar with the use of video, computers, and the internet as resources for professional development and as tools for improving teaching and learning, and (7) enable teachers to build a new notion of curriculum based on their construction of inquiry-based science teaching.

Throughout the semester, students looked at video clips of real-life classrooms investigating a variety of science topics and reflected on the teaching strategies they saw. Course readings spurred further conversations around topics such as questioning, group work, materials management, and classroom culture. In order to experience the inquiry process firsthand, the class collaborated on a simple investigation of rust. They also conducted their own individual classroom study addressing a topic of their choice. This study included making hypotheses, observing their own classrooms for evidence, analyzing data, and finally presenting their results to their peers.

Science K-6: Investigating Classrooms Web Course was structured as an online course with two scheduled face-to-face meetings. The first meeting was scheduled at the beginning of the course to ensure that participants were comfortable using the class web page and were informed of the course outline and expectations. The last meeting, held at the end of the semester, was to share the outcomes of their individual studies.

All other class sessions were held via the web. In these sessions, students logged on to their computers to post messages to online web boards. During the semester, students completed readings, watched videos of classroom practice created by WGBH in Boston, engaged in scientific and classroom inquiry projects, posted reflections about their investigations to the web site, and responded to the postings of other participants. The instructions for carrying out these interactions over the Internet were described in detail during the first meeting and subsequently on the course web site each week.

The Projects

Rusty Nails

During the first class, teachers were introduced to the rusty nail activity that would serve as a long-term inquiry project during the course. I opened the activity with a question about my 1990 Nissan Pickup truck. After recently moving to Massachusetts from Nevada, I came to find a hole, crusted with rust and about the size of a quarter, on the bed of my truck. I conveyed to the class my shock at finding this! Although my truck had been on the road since 1990 when I bought it in Illinois, I hadn't seen a sign of rust until that fall. As I showed them color overheads of the hole in question, I questioned the group: "What had cause this rusted hole?" "What is rust?" "What was the prognosis for my truck?" After some discussion of what they knew about rust, the group was charged with making two nails, devoid of any protective covering, as rusty as possible. They were to design their own investigations to explore their questions around rust.

This project was designed to give the entire class a common experience in carrying out a scientific investigation. Using the phenomenon of a rusting nail, they made predictions, designed and redesigned experiments, made observations, and ultimately drew conclusions about their studies. They posted three Lab Reports on the web site about their observations, and they recorded information about their investigations in a Science Log.

Classroom Study Project

About a third of the way through the course, the teachers were asked to engage in another form of inquiry—classroom inquiry. In this project, teachers designed and implemented a study of their own classrooms to find out more about the factors that affected the way their classrooms worked and how their children learned. They had several weeks to design and carry out their studies, collect and record information in their Personal Journals, consult with an online study group, and finally present their results in a paper and lesson modification during the last class meeting.

Participants & Methods

Participants in this study included the three instructors and seven of the teachers enrolled in a 14-session, graduate-level science education web course.

Data was collected in the form of 1) pre- and post-instructional surveys, 2) interviews, 3) web postings, 4) journals, and 5) course documents. Pre- and post-surveys were used to investigate participants' beliefs and attitudes about science, teaching and learning, and previous skills and experience with computer use. Surveys provided demographic information, informants' perceptions of what they experienced as a result of their course activities. Participants completed surveys at least twice--at the beginning and then at the end of the project.

In-depth interviews and semi-structured interviews were used. Interview protocols were developed to probe participants' conceptions of teaching and learning and their practices as teachers. Interview questions in this project focused on participants' beliefs and attitudes about students' learning and their teaching science, their experiences within the project, the significance and interest level in science activities, the benefits they received from the project, and the obstacles/limitations they encountered. All interviews were approximately 60 minutes in length, tape-recorded, and later transcribed. Pseudonyms were used throughout the analysis to maintain the individual privacy of the informants.

Documents include those associated with course such as syllabi and student work. Artifacts that described the beliefs and instructional practice of teachers included: lesson and unit plans, examples of student work, journals, and logs.

Data Analysis

Researchers used the National Science Education Standards to assess the professional development of teachers. Data was analyzed using the coding of qualitative data and domain, taxonomic, and componential analysis to determine critical patterns and themes (Spradley, 1979, 1980). Data sources were compared through the process of triangulation. The analysis includes particular description in form of direct quotes, general description in the form of taxonomies, charts, and diagrams, and interpretive commentary (Erickson, 1986).

Results

An intersection of several factors enabled the teachers in this course to legitimately participate in science activity and discourse. As in a previous study (Davis, 1999b), I came to find that the use of computer technology (in this case, the Web) was not in and of itself the key factor in women's participation in science activity and talk. Instead, the use of computer technology in conjunction with a myriad of other factors came to bear in their engagement in science and its discourse. Key elements to their participation were: 1) engaging in the process of inquiry—"doing science," 2) having a say in their science process, 3) communicating with others about their science activity, in this case, via the Web, and 4) linking their own methods of inquiry with those of their students. The use of technology in this course, provided participants with new and more ways to access and engage in science activity and talk. However, there were some technological barriers to their science talk as well. I discuss these issues below.

Engaging in the process of inquiry—doing science

In their interviews, journals, and postings on the course web site, teachers in the course reflected upon their personal science learning in the class and the science learning of their students. They painted a picture of learning science through "doing," which included engagement in inquiry, reading scientific literature, and interacting with others.

Teachers' engagement in the inquiry project aided them in their use of the process skills of science as outlined in the National Science Education Standards (NRC, 1996). (See Table 1.) For example, Michelle, a computer teacher and previous art major, documented her exploration of rust in her Science Log and in her Web postings. Illustrating the cover of her Log are words that describe the process of inquiry—Question, Experiment, Experiment, Question, Record, Analyze, and Explain. In her journal, she notes her initial thoughts and questions:

1) Salt…road salt "eats" cars, fine sand and salty moist air is why we are advised to hose our cars off after a trip to the seacoast. What is the role of salt? How does it participate in the rust process?
2) I think if I scratch up one the nails to expose more surfaces to the salt water, that will encourage faster rusting. What am I going to scratch that small surface with? Another nail? A wire brush?
3) Why am I thinking about this "expose more surfaces of the nail?" What do I think rust is and why do I think smaller or thinner pieces of metal will get rustier, or rust faster than a denser piece of metal?
4) Why do I think that these nails are made of the same metal that cars are made of? What kind of metals are nails made of? And cars?
5) If salt water will rust metal faster than fresh water, why are ships and boats that are made of metal allowed on the oceans?

Michelle then designed her investigation. Below, excerpts from her Science Log document her process. In bold type, she noted her reflections about her observations and her hypotheses.

Lab 1 Rust Is A Sign of Neglect

When Dick told us that our nails had "been treated with a substance to remove any oils from their surface", a couple of us immediately dropped said nails. (I heard their pleasant clinking on other desks than my own.) **1. Nails are not protected from the producers of rust.**

I put each nail in its own (expendable) saucer. One on the kitchen counter, one on the porch. Each nail sat in a puddle of water. In a few hours (If I knew rust happened so fast I would have measured the time then!) [the] inside nail was "bleeding rust", outside nail was encased in ice, not rusty. **2. Cold preserves nail. Warmth encourages evaporation, which seems to promote rust.**

2.A. Have to re-do [the] experiment for time measure.

...Outside nail is slightly rusted, but took longer because snow and ice preserved nail. Inside nail needs more water added constantly. It is very cruddy, flaky, big rust. The rust on outside nail is fine textured, not nearly as extensive.

3. Rust can be a sign of careful, deliberate care to cause rust. I want to think about "why salt" before I do salt. Also need more nails.

Lab 2 Only one Variable, and :^(only one nail :^(

When I get more nails (when I paint my masterpiece) I will start with more variables.

Meantime, my experiment was limited to observations on the effect of temperature. On one of the web sites, I read that "heating of the iron can induce rust." I began pouring a bit of boiling water over the "inside" nail (which is in a saucer) each time I made a cup of tea, or instant coffee, about 3 times a day.

The problem is not having any way to measure, to explain how rusty the nails are or are not. This only: When cold tap water was used, the rust process was slower. (How slow?) The rust was finer. (How fine?) NOW: After the boiling water treatment, the rust is flakier. (How much flakier?) I BELIEVE the nail looks skinnier. (A caliper, do I need a caliper?)

Last snowstorm, my "outside nail" disappeared. Everyone here denies having anything to do with the disappearance. Could the wind have actually blown a saucer off the porch?

Lab 3 Why not Salt? Why not Pepper?

By Michelle

In my own nail investigations, I focussed on temperature. I decided that the second lab report and my second experiment did not have particular enough controls to help verify the effect of variables.

Experiment #3

Controls: 3 new nails

3 white china bowls

sodium free spring water(Indian Rock)

Variables: 1/2 cup room temp. water

1/2 cup boiling water

1/2 cup water with 6 ice cubes added

Hypothesis: because I read that "heating iron will cause it to rust quicker", and my first experiment showed that the nail in the warm environment rusted sooner and further than the nail in the cold environment, I predict that of the three temperatures, the nail in the boiling water will rust sooner and further than the other two. I further predict that the nail in the bowl with ice cubes will be the last to rust.

Observations: The first nail to show signs of rust was the nail in room temperature water. The last nail to begin rusting was the nail with ice cubes.

Conclusion: This brings up questions. Were the nails really identical? I didn't wipe them off with vinegar or lemon juice, just took them out of the box and put them immediately in a container to avoid contact with my skin oil and moisture.

Did the increased volume of water caused by ice cubes skew my experiment, and reflect volume of water as a variable rather than temperature?

Does very hot water impede rather than induce oxidation of the nail?

Is the process of boiling an oxidation-reduction reaction? Is steam oxidized water?

I boiled the water in a stainless steel pan, because the inside of the enamel teapot has rust stains in it. I happened to let the bottom of the pan get scorched after I measured out 1/2 cup of water into the bowl. The scorch mark is the same color as rust. Is it rust?

Any way, judging by my three lab reports concerning temperature and rust, it seems constant that very cold does not induce rust.

Jumping to Conclusions: David, being intrigued by the heat question, and what I learned from the Internet (a valid source?), we assumed that it would have to be real hard heat that would turn the nail red, like in a kiln or burner flame May be this simple experiment of mine says that boiling hot is hot enough, or even a degree or so cooler will do.

New Design: requires more mat'ls. Bunsen Burner, thermometers (to be exact about temperatures) more bowls, more nails, and I would like some way to keep temperatures constant. One nail encased in ice, and watch it to see if it rusts ever so slowly (in experiment #1 the outside nail was always cold, but fluctuating degrees of cold.) The red hot nail could not be kept at a constant temp for long, and when plunged in any water would cause steam, like a blacksmith does (how did folks invent that process...hmmm)

The overall topic of study for the project was predetermined by the instructors; however, teachers had a great deal of say and ownership within the project as they decided the questions to explore, the design for their experiments, what was important to observe, what data to collect and how to go about it, how to resolve problems, and how to redesign. (See Table 2.) Teachers interpreted their data and constructed their own understandings based on the results of their investigations.

Communication

The use of technology in the project fostered communication in many ways. Teachers: (a) interacted with others about their inquiry, (b) critiqued their investigative process and recognized and analyzed alternative explanations and predictions, and (c) collected data from outside resources. In addition, the structure of the course provided the students with more space for talk than the traditional classroom context and, for some, a more comfortable space.

Interaction about Inquiry

While interacting with others about their inquiry via the website, teachers were able to communicate ideas, feelings, and experiences regarding their investigations and provide others with alternative ideas, critique, suggestions, questions, and encouragement. (See Table 3.) Christine commented:

> The actual back and forth was useful getting people's comments -that was interesting....There was a diversity of experience and background among the

> students. Some were perhaps asking more sophisticated questions and others, but they were all kind of actually kind of interesting questions, interacting back and forth on them you make connections between them....They would bring up questions you might not had thought of - that was useful, helpful....By encouraging everybody to comment on everyone else's questions and statements encouraged people to really look at other people's way of looking at things and that doesn't happen often among peers and which you wouldn't have necessarily done if [you] were in a regular class.

Mary stated:

> I found myself asking questions of everybody. "Where should I put - how should I put it - can you give me a really good idea" because I want to tap into the best ideas of everybody.... I think it was open-ended kind of questions that we had in the web course - getting onto the web and reading through some of the stuff that other people wrote... I felt more grounded because some their stuff wasn't working, or they had questions and I said "Oh thank God", so now I can do something silly like that too and not feel bad. So I would say it was the inquiry part of that piece of it that was really important.

Michelle noted:

> I think everyone ran into problems with the course; the encouragement made such a big difference. You don't necessarily find that in every course that you take, and the atmosphere that was created was one of cooperation more than competition, I think. I think I felt that really strong.

Michelle's investigation experiences provided a good example of the interactive discourse that took place among the teachers in the course. In her second lab report, Michelle publicly described her struggle to quantify the rusting of her nails she had placed under different conditions. In her journal, she noted how, missing this element to her investigation, she found it scientifically wanting. In her journal she stated:

All the teachers are designing their own experiments and doing them, and commenting on each other's variables, and controls, observations, conclusions, and questions. These are mine, so far. They are not what I would call the most scientific. I believe that some of the other teachers' experiments are more scientific than mine. Why? Because I didn't measure measurable things, like how much time, how much water, the exact temperature.

Course participants and instructors responded to Michelle's queries about a way to measure the quantities of rust on her nails with encouragement and several suggestions. Below are their comments.

Comments on "Only one Variable, and :^(only one nail :^(":

Only one...only one! Mary
- at 12:17pm Mar 28, 1999 EST
(With apologies to Bill Cosby for stealing that line from his Noah routine!) I couldn't help a chuckle over the mystery of the missing nail. Any wildlife which could have stolen it? I, too, am looking for a way to quantify the degree of corrosion; a fine scale before and after? scraping off the rust and weighing that? I am open to ideas. I am currently estimating it crudely by the depth of the sediment on the bottom of the jars, but that is pretty rough. Perhaps the effect of temperature is marginal? I, too, have trouble trusting my experimental technique and design. I keep thinking of things I forgot to control...(sort of like my life, these days...!).

Measuring Rust () Carrie
- at 02:28pm Mar 28, 1999 EST
You say you have a problem, not being able to measure or describe how rusty a nail is... Is this a good next idea to focus on as you plan your further rusty nail investigations? Could you create a descriptive scale upon which you could rate your nails? An interesting idea!

reply to Michelle () David
- at 04:43pm Mar 29, 1999 EST
Carrie's suggestion is a good one. How can we set up a scale of "rustiness." In the meantime, I am fascinated by your question about heat deterring rust when a nail is treated by heat. I'll bet a dollar to a doughnut that they mean real hard heat. Like a flame from a burner. A minute or so of treatment or letting it get red hot could be a good bet since that would probably "harden" the metal like they do at a blacksmith's shop. Interesting. I'll be interested in what you decide. I'll look for an experimental design soon.

to Mary, Carrie, David () Michelle
- at 11:05am Mar 31, 1999 EST
Thank you for your comments! It occurred to me the other day that weighing the nail would be a measure, better perhaps than a caliper. I like Christine's idea of measuring the rust scrapings. I agree with you all that some kind of design has to be made to depict and communicate, to let us rusters know, as well as convey our beliefs to each other.

I think I may be getting behind, because I am not online at home, and my times for being on this site, and posting, are limited. Further limited by error messages from the computer (whose server is down?). But I will continue to post when I can. Sometimes I get a whole posting typed and it won't go through, sometimes access to the next page is restricted, and the message says "document done".

Rust ruminations () Mary

- at 12:17pm Mar 31, 1999 EST
Re: rust weight, I don't know where to find a scale with fine enough measurement capability, though maybe they have one at the HS. It was just a thought born of frustration. Good luck with your computer woes!

In her Science Log, Michelle recorded how she followed through on several of the suggestions provided, and some new ideas of her own, to record her observations and measure the amount and kinds of rust on her nails. She drew pictures with the aid of computer graphics. (See Figure 1.) She took photos, but found them misleading. (See Figure 2.) She devised another system where she took the nails out of their saucers and put them on the kitchen counter at a distance from each other. Pieces of rust fell off each nail. Scotch tape was used to pick up the rust from each nail and placed on white paper. (See Figure 3.) She suggested "a possibility for measurement."

> Could there be a tool (wire cutters?) which would cut through nail fairly easily without squishing the metal? So that we could look at a cross section and see how much nail is affected by rust. Maybe our sight could be helped by a magnifying glass. (See Figure 4.)

She also devised a "verbal scale for rustiness" or defined various types/stages of rust. (See Figure 4.)

What was fascinating about this process of student reporting and interaction, was the students' ability to question and self-critique their investigative process. This was a component of each participant's inquiry process whether it involved reassessing preconceived ideas, acknowledging the need for more study, or rethinking their investigative design. (See Table 4.) The interaction between students appeared to facilitate their inquiry process.

Collecting Data from Outside Resources

The design of the course encouraged students to look to outside resources for more information to help them with their investigation of rust. During Session 3, students were asked to "surf the Web for information that might help you in your new experiments" and, during session 4, "conduct a web search to collect information about your science investigation. Add web sites to the class Library by posting briefly annotated choices of good sites to the Library under New Web Sites."

Michelle began her quest to find out more about rust as she designed her first experiment. She went to the web and "asked Jeeves" (www.askjeeves.com): "What kind of metal are cars made of?"

Sheryl found that her use of the Internet has opened up a new way of learning and communicating for her and her students.

> There [are] a lot of different web sites that [can] be...accessed... and, without the Internet, those channels for information [aren't] open. I have a lot of bookmarks on my computer, right now, that are through WGBH and some that I gathered from that class. All I can say is that when I first started teaching. I used a textbook and that was it. I mean I showed movies, supplemental activities, and lab, but the text was very important. I think now what I'm doing...I'm having the Internet and the web sites that are available as a source of information a lot more than any textbook.

A Big, Safe Space to Speak

Course participants related that, although initially they may have had some uneasiness posting their ideas for everyone else to see, they felt that the format of the course provided a safe place to share. Michelle pointed out:

> It [the course] was a little bit scary then it was fun...sometimes I'm very critical my own writings....Posting responses...and not be in a person to person setting--sometimes I would go to the library online and see, I think it was Mary, she was always first - and always thorough. I would be like "errrrrr!" But what was good about it was that I thought she was very bold. I think what I'm trying to say is that I was scared and hesitant to post something not knowing how it was going to look. "Is this what they're looking for?"
>
> Some people, myself included, will inevitably sound better on paper after I have chance to edit, think it through. When I think off the top of my head, I will maybe get

> so many ideas at once that I either stop communicating or I digress and try to jump back and can be hard to follow. So this way would be easier for me in terms of...style of communicating.

Mary pointed out:

> You know it was motivating to go and see - I wanted to see if anybody answered my thoughts, you know, like when I posted a message. I always went to see if anybody answered. Maybe now that I'm not so afraid of science, I might enjoy an adult science course, but I really don't know. I don't think I would ever sign up for one for fear that I would be the least knowledgeable person in class. Over the Internet, it was more comforting to know that I was just out there in Cyberspace, and nobody really knew me, and I could type in anything. "Do you remember her?" - "No." (laughter) That kind of thing. The anonymity was comforting. (laughter) I could ask a silly question, or I could ask whatever and write it...and no one was going to say, or I wouldn't have to see their faces in disbelief that [I] asked this question. And people wrote nice [things] back, "Oh, I know what you mean." That was a nice part of it.

The format of the course also allowed more space to talk. There was no opportunity for interruptions from instructors and other students; there was not the responsibility to "share air time" with others. There was no limit to how much one could report about whatever. Michelle pointed out:

> When you post your responses - it's different than sitting in a classroom setting where not everyone might get a chance to speak.... Some people in a group discussion want to talk to all the time, not that they don't want anyone else to talk. So you have that kind of group dynamics that the design set-up eliminated that which can be problem for all teachers and learners.

When the participant interaction is mapped out for the three Lab postings, there is a notable amount of student-to-student interaction. Course participants were only required to respond to one other student. However, conversation maps show that there was a great deal more interaction that took place. (See Figures 5, 6, & 7.)

Christine described how different this was from a traditional course:

> Frequently, you might interact with people you know in the class but you don't have to interact with everyone in a class...unless you're in a small seminar type.... It's usually...more the teacher has set-up the issues you're going to discuss....[There was] certainly more [peer communication] than a lecture course - even more than a lab.

Constraints to Communication

Many participants experienced constraints when it came to communicating with their peers during the course. Concomitant with the amount of time required for the reading of comments and the posting of responses, not everyone could readily get on-line: the lines were busy; the server was down; they did not have a modem at home or a computer; they used a computer at school or a local library and it was not always available. Also there were technological snafus that often appeared and interrupted students' ability to post messages and their work for the class. Michelle's posting highlights several of these problems.

> **to Mary, Carrie, David** () Michelle
> at 11:05am Mar 31, 1999 EST
> I think I may be getting behind, because I am not online at home, and my times for being on this site, and posting, are limited. Further limited by error messages from the computer (whose server is down?). But I will continue to post when I can. Sometimes I get a whole posting typed and it won't go through, sometimes access to the next page is restricted, and the message says "document done".

Michelle explains her problems in detail:

> I was not on-line at home, and so I reasoned that I could work on the course during my lunch break at school and otherwise at my library, which is on-line. And there were a variety of things which tended to impede any work getting done. We have changed Internet service providers at the school, and I had a terrible time with that, because some of the times we couldn't get on-line. I couldn't bring up the Web site for the course. And at the library, you have to sign up for time. It's a very popular activity at

> the library, to go on-line--all ages of people do it. It felt like everybody... wants to use the library computers to go on-line. And then, so, therefore, I would have to wait. You're limited to one hour [at a] time. One day... I spent three hours on the course. And I figured this to be an average per visit, because I would read the comments that my colleagues had written, respond to their comments, and then also read my assignments and...post whatever work I could. And it was all really enjoyable, but it was time-consuming and got frustrating when there was somebody behind me in line and I only had an hour, and I still was having some problems getting on-line, getting to that Web site at school....Then, eventually, I found that I had to get on-line myself, and I took advantage of AOL's offer for, I think, one month free, and that was much more pleasant, working at home on the course.

Getting on-line and staying on line was an issue. Christine reported, "I occasionally got in trouble when I got kicked off the Web, and then I had to get back on because I'm on a remote access and occasionally my thing would hang up and I would have to finish typing and put it back on again."

There were also complexities participants experienced as they tried to negotiate the web site. Christine pointed out, "The main problem I had was [that] the site was very complicated. I had to check about 15 different places to find everything. So that was a bit cumbersome in terms of design of the web page."

Despite these constraints and though the course required students to spend a lot of time with assignments, reading responses, and postings, several viewed the web as a good means to communicate that also eliminated travel to a course site which also served as a constraint to their pursuing professional development activities.

One limitation of the web site was the fact that course participants could not provide either photos or drawings to illustrate their observations. Several of the teachers' Science Logs contained either drawings made by hand or by computer as well as photographs. (See Figures 1, 2, 3, & 4.)

Students' communication might have improved if they had been able to add this dimension to their communications with each other.

Making the Link to the Classroom

Interesting to this context is how the teachers' own experience with inquiry acknowledged and influenced them to provide students with autonomy in their science learning. As a group, the course participants saw that as they were given a great deal of autonomy in their science activity (See Table 2.), it was important to "[Let] the children have the reigns more."

Mary thought that the student design aspect of the web course was the most challenging and yet it helped her see the openness of science and how she could be more open-ended in her teaching. She said:

> I felt comfortable…just knowing to come in and say, okay, this is the question. What are all the different ways we can look at the question. Feeling like there were no tidy boxes or correct answers. The most important thing was the inquiry - to get kids interested and stimulated thinking. Where it went from there okay….I think I'm much more open ended. I was always open-ended - it's kind of my personality but I think I'm much more open-ended now.

Michelle shared:

> I liked the project we had. I liked how different students approached it differently that was no right way, no wrong way. Some maybe could be called more scientific than others, but we were all being scientific. The experiment was always to [decide] what materials to use and to think about "Why?" To be given this idea, this project and then to have my mind open to the questions--so many more questions came --learning to love the questions. It was just - I keep using the words fun and entertaining but it was an enlivening experience because it made me feel happy to be alive. This is too funny. I'm thinking about rust. I'm noticing rust everywhere and I now…[and] have my 5th graders…think about rust, to notice rust everywhere. Who would have thought there would be so much concern about rust?

Michelle, a computer teacher, described how the students in her computer class engaged in the rusty nail activity with her.

> The fifth graders… rusted nails, yes, because I'm not, per se, a science teacher…. Seeing them only once a week, it was a perfect project when I was rusting my own nails at the same time. What does this have to do with computers? What do we do with the computer?….[W]e had access to the Internet, some research. We did searches on rust, and we came up with new vocabulary words to learn such as galvanized and learned that there were businesses that were very actively interested in preventing rust. We also used the computer for word-processing to make a list [of] where the children had observed rust through the weekend – that was their homework. Then on Monday, we typed it up.

"Things seem rather out of my control," Michelle wrote in her journal, "but the children are thinking and planning." She explained their process:

> At the very, very end…the fifth grade had… made up their own experiments – what they wanted to do was to see what substance would rust nails faster or retard rust and so on….Experiment #3, they don't want to hear about variables. I partake in experimenting with them, explaining why I am using two bowls, one with salt and one w/out salt. Someone adds a galvanized nail to each of my bowls. And a threaded nail for good measure. The threaded nail was first to rust, as we predicted, and it happened to be in the salted bowl. No threaded nail was in the unsalted bowl to be a control. The galvanized never rusted--yet. Although we had talked about galvanization, and I showed info on a web site about it, one student was intrigued by these nails and asked," Why didn't those get rusty?"
>
> "Those are the galvanized nails."
>
> "What does that mean?"
>
> Now she's engaged in inquiry.

One girl suggests that we do a bowl with pepper, too. I begin discussing why not pepper, and realize there's no reason why not. Meantime, being put into the bowls are all materials at hand: chalk, ink, cardboard. I ask each team what their theories are. The experiment has changed. It is truly their own. They also decided on their own to use a variety of nails.

One child showed me that he was going to rust a nail quicker by coating it with Vaseline. "What will the Vaseline do?" I asked. "Add moisture and keep the moisture in so more rust will happen." The next week he was SO EXCITED. "I made a discovery!" he crowed. "Vaseline prevents rust!!!!!"

[T]he bowls, which were white Styrofoam, had all different colors in them and there were all different stages of rusty nails. I kind of wanted the younger kids to see them because it was fascinating and probably also because maybe I'm a crazy lady, I don't know – as an artist as well the whole thing looked like art to me as well as science. It was sort of like a still life with "rusty nails" pictures. It was beautiful!!!....The younger children were very intrigued by it and they had a lot of questions....They said, "Are you still going to be teaching computers when I'm in fifth grade?" "This is what you do in fifth grade." It was a very exciting time.

Michelle indicated that, as a result of her experience, she "will be less rigid...about maybe naming things and have more activities oriented. Instead of dealing with vocabulary first, the vocabulary will come last. Instead of telling students what they will find, asking them what they found.

And you know that approach was almost too unusual for some of my students as well as my own children....My children and I were getting [in] those strollers and were out by the reservoir when we saw streams - and it was rusty streams. Every little rock and pebble was covered with rust. My older daughter asked, "Why is that stream all brown and rusty?" Instead of saying, "Well, it's ferrous oxide....", I said, "Why do you think?" and that's not what she's use to.

> Also [a] student that I have...brought in a science book and said, "Here's a real experiment we can do - which goes like a recipe - just get this all together this way and you'll come out this." That seemed to suit her better than "here's some material and go do an experiment" kind of attitude. So I think we always knew this: there are some people who want to have it very structured and you encourage them to take the reigns a little more themselves. There are others who can go and run with it.

At the beginning of the course and then, again, at the end of the semester, the teachers were asked to capture their beliefs about teaching and learning in a metaphor. Their metaphors changed over that time indicating a change in role as teacher, generally from that of a director to more of a facilitator. Christine stated in her final paper:

> In February, I set out two possible metaphors...teacher as a guide in a vast, exotic bazaar, and the teacher as a quilt maker....When I described the bazaar, I was primarily concerned with a variety of experiences, a choice of many interests or directions....I saw myself as a mapmaker, helping students to filter and organize their experiences....I see my role as a more active leader now, helping students to explore, but bringing them back to...write their travelogue—to describe and make meaning from what they have seen and to communicate that meaning to others. I need to ask questions, encourage them to ask and reflect about what they are seeing.
>
> The quilt maker...I would see myself as helping to provide a stout backing on which students can fit their designs....students need to be encouraged to plan out their designs....I need to help them display the whole...and to make connections with other learning.

Mary moved from Master Chef to Head Nutritionist. She indicated that her role was to "monitor the concepts that the children are forming, directing, and clarifying their meaning-making." Now "they are the chefs who are creating for themselves scientific meaning."

Michelle revised her view of herself as Rumplestiltskin and Mary Poppins "where I was the action, the center of attention....Remember the old tale by Marcia Brown about the peasants who seemed to have nothing to eat, nothing to share with the wanderer who…told them they could make soup from a stone?" In her new metaphor, Michelle is the stone. "Not quite as inactive as the stone," she said," but I am at the bottom of the cooking kettle. I have always been with them, the student community. Eventually they will find out they can "make soup" without me. The great importance of the stone was that it made the people curious and willing to get involved."

Conclusion

In sum, the scientific activities and means of communication embedded in the web course, outlined in this paper, provide a good model for an inclusive pedagogy for females. Meaningful and autonomous activity in scientific inquiry was key to the legitimate participation in science of the women enrolled in the course. They had much say in the questions that were asked, the designs of their investigations, the critique of their exploratory process and thinking, and communication of what they observed, thought, and questioned. This provided them with a science that was "authentic and constructed" instead of "received and reproductive" (Hildebrand, 1998, p. 349) and a meaningful context for discourse.

Though scientific discourse is often blanketed in competition and aggression, this setting was rich in science talk and cooperative and constructive. The web context and the design of the course provided an inviting setting for participants to share their inquiry process, read the science doings of others, reflect upon their own explorations and those of their peers, and provide support, ideas, and suggestions. Though non-competitive and non-aggressive critique is often difficult to establish in classroom settings (AAAS, 1993; Lampert, 1990), the web course appeared to provide such an element in the learning process. In fact, the talk of the course participants greatly mirrored the talk of the Women in Science (WIS) group described in this author's previous research (Davis, 1996). Indeed, as described earlier in this paper, the discourse of the WIS group was based on acquiring and sharing information. Within the group, the members would question others for information; share personal knowledge and experiences; make suggestions; tell stories; describe situations and events; give examples; advise; and report on activities and practices that individuals had tried out. In both the WIS group and the web course, participants found the setting to be supportive and critical to their learning process.

Finally, the use of computer technology in this context, was a great enabler of participant interaction and science talk. Compared to the traditional classroom setting, there was more space for individuals to explain what they were about in their explorations and more opportunity for peers to view others perceptions, experimental designs, and findings. The web context allowed for more opportunities for dialogue between participants than one would find within the confines of even a 2 1/2-hour graduate course. Though missing the possible social advantages of face-to-face interactions, the web course design provided a discourse-rich setting.

In sum, this researcher is finding autonomous scientific inquiry is a critical element of an inclusive pedagogy. Such activity provides learners with meaningful activity about which they can talk. Computer technology continues to offer learners with many venues to communicate their understandings, activity, and questions. For females' legitimate participation in science and science talk, these approaches must be considered.

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Table 1.

Engagement in Inquiry

Inquiry Descriptor/ Participant	Michelle	Mary	Sheryl	Matt	Christine	Linda
Ask a question about objects, organisms, an events in the environment	X	X	X	X	X	X
Identify questions that can be answered through scientific investigations	X	X	X	X	X	X
Plan and conduct a simple investigation	X	X	X	X	X	X
Design and conduct a scientific investigation	X	X	X	X	X	X
Employ simple equipment and tools to gather data and extend the senses	X	X	X	X	X	X
Use appropriate tools and techniques to gather, analyze, and interpret data	X	X	X	X	X	X
Use technology and math to improve investigations and communications	X	X	X	X	X	X
Use data to construct a reasonable explanation	X	X	X	X	X	X
Communicate investigations	X	X	X	X	X	X
Communicate explanations	X	X	X	X	X	X
Think critically and logically to make the relationships between evidence and explanations	X	X	X	X	X	X
Recognize and analyze alternative explanations and predictions	X	X	X	X	X	X

Table 2.

Student Autonomy

Participant/ Project Descriptor	Michelle	Mary	Sheryl	Matt	Christine	Linda
Students' interests are acknowledged & addressed	X	X	X	X	X	X
Students' skills are acknowledged & addressed	X	X	X	X	X	X
Students' questions are built upon	X	X	X	X	X	X
Students' ideas are built upon	X	X	X	X	X	X
Students set goals	X	X	X	X	X	X
Students plan activities	X	X	X	X	X	X
Students design the environment	X	X	X	X	X	X
Students assess work	X	X	X	X	X	X
Students explain and justify their work to themselves and others	X	X	X	X	X	X

Table 3.

Benefits of Communication

Participants/ Kinds of Communication with Others	Michelle	Mary	Sheryl	Matt	Christine	Linda
Share ideas	X	X	X	X	X	X
Share feelings	X	X				
Share experiences	X	X	X	X	X	X
Provide others with alternative idea	X	X			X	
Acknowledges others difficulties as their own	X	X			X	
Asks questions	X	X			X	
Provide others with critique					X	
Provide others with suggestions		X			X	
Provide others with encouragement	X	X		X	X	
Expressed appreciation for comments of others	X	X		X	X	

Table 4.

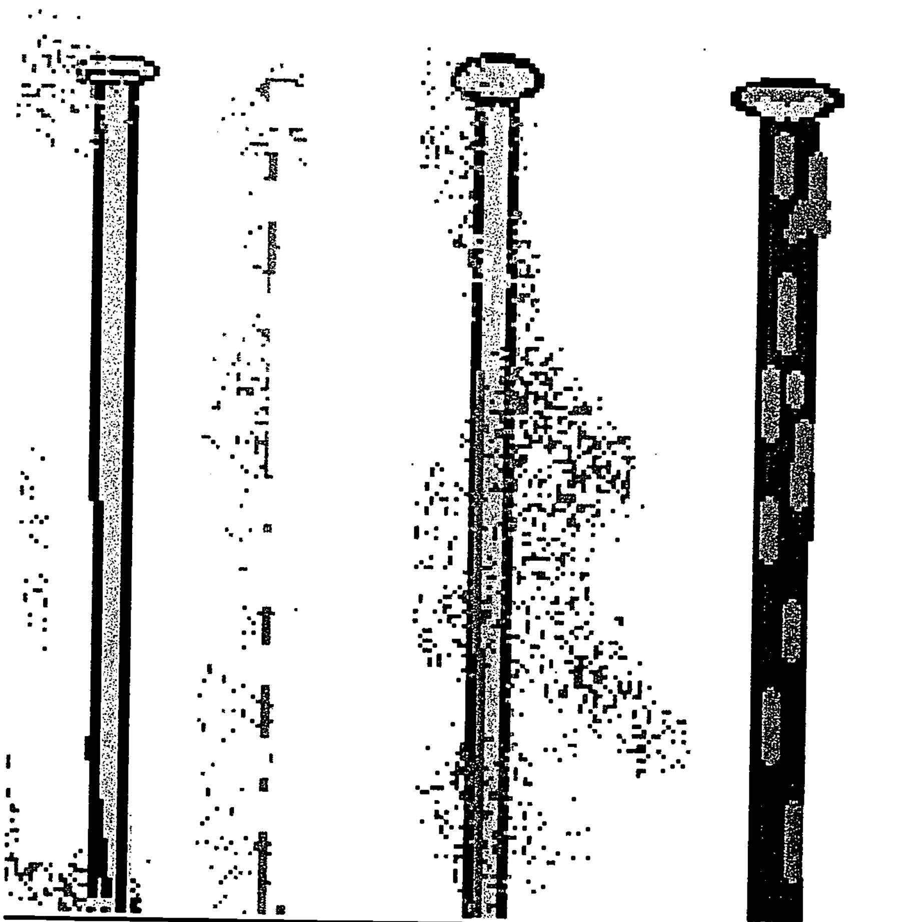
Kinds of Critiques

Participants/ Kinds of Critiques	Michelle	Mary	Sheryl	Matt	Christine	Linda
Preconceived ideas	X	X	N/A		X	X
Need for more study	X	X	N/A	X	X	X
Methods of investigation	X	X	N/A	X	X	
Need to control for variables	X	X	N/A	X	X	
How to/need to quantify/measure	X	X	N/A		X	
Outside factors influencing results	X		N/A	X	X	
Results when compared with the results of others	X	X	N/A	X	X	

Observations

When nails immersed horizontally in a puddle of water, in shallow white china bowls, first begin to rust, they seem to "bleed" rust; the liquid appears to obtain a solution of color that oozes away from the nail, and later settles under the nail, near it, in an outline shape of the nail.

Later, when nails get rustier, the rust is no longer a sediment of fine powder, but appears in large flakes all over the nail.



How CAN we set up a scale of rustiness?

a verbal scale for rustiness

rust blood or powder oozes from immersed nail, sinks to bottom of container

small flakes float away, specks are visible

large flakes mostly stay on nail, looks like shag-bark

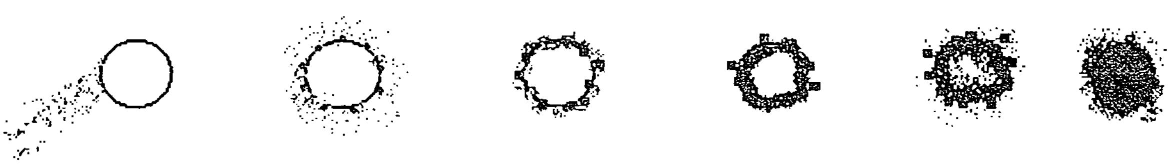
cruddy rust is deeper into nail

decrepit rust reaches to core of nail

ash stage nail can be broken or crumbled by bare hand

a possibility for measurement

Could there be a tool(wire cutters?)which would cut through nail fairly easily without squishing the metal? so that we could look at a cross section and see how much nail is affected by rust. Maybe our sight could be helped by a magnifying glass.



Most possible:

Rust Droppings

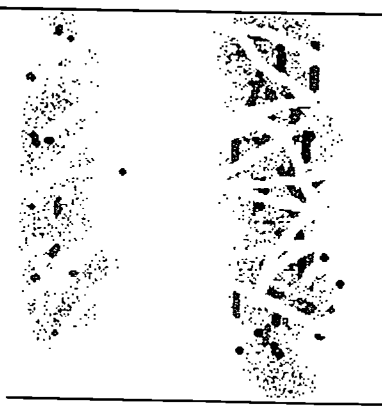
Nails were taken from initial experiments (two nails). A photo was taken of the nails after all water had evaporated. After the photo was developed, it was found to be misleading. Due to the addition of salt, the rustier nail appeared lighter in the picture.

Next, nails were taken out of their saucers and put on the kitchen counter, at a distance from each other.
Pieces of rust dropped off each nail. Scotch tape was used to pick up the pieces of rust from each nail.
An experiment design to use this measuring method would be to use variables of
1.refrigerated nail
2.room temp. nail (varies,so maybe in air-conditioned place)
3.outdoor nail (summer/keep track of daily-nightly temp. fluctuations)
4.nail w/salt (tablespoon)
5.nail and batteries and salt(read in postings,)
Equal amounts of water, measured time, notice how long water takes to evaporate.
Then pick up rust from each nail on scotch tape, and stick tape to white paper.

Example

Outside nail

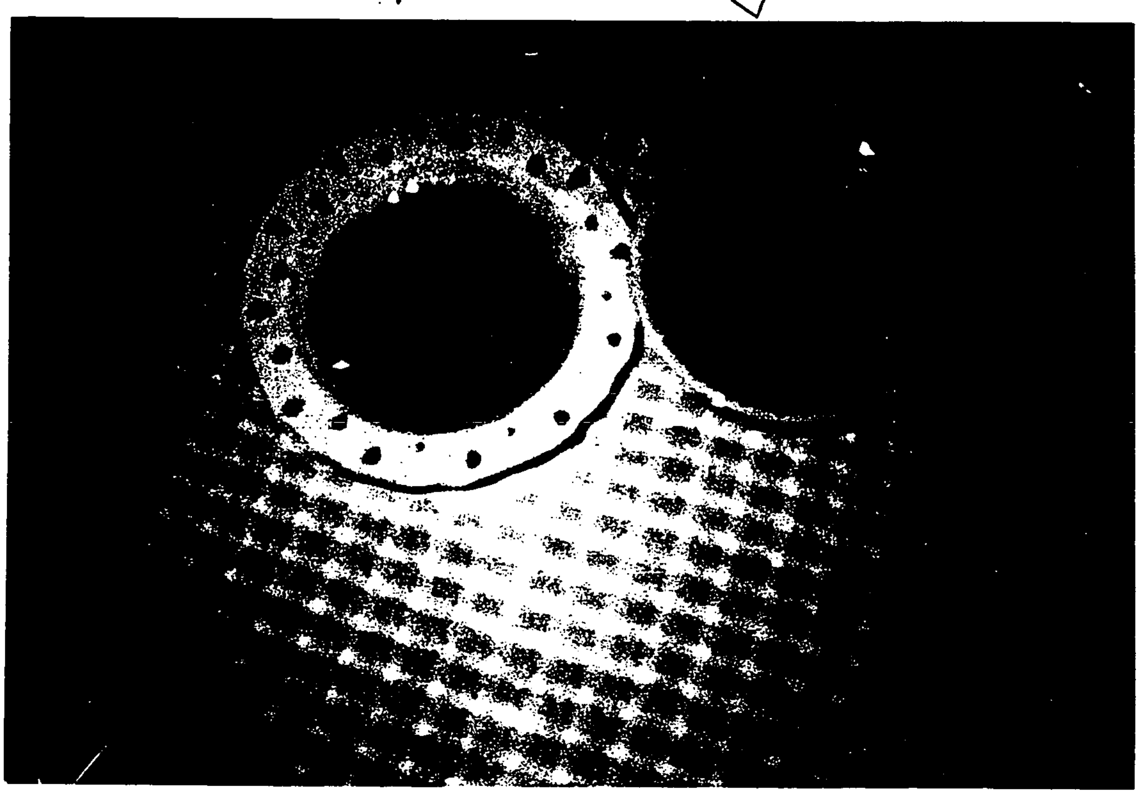
Inside Nail



"Indoor" Nail
salt and warm water
occasionally boiling water

"Outdoor" Nai
winter
mostly encased e
later just left i n

INOOR OUTDOOR



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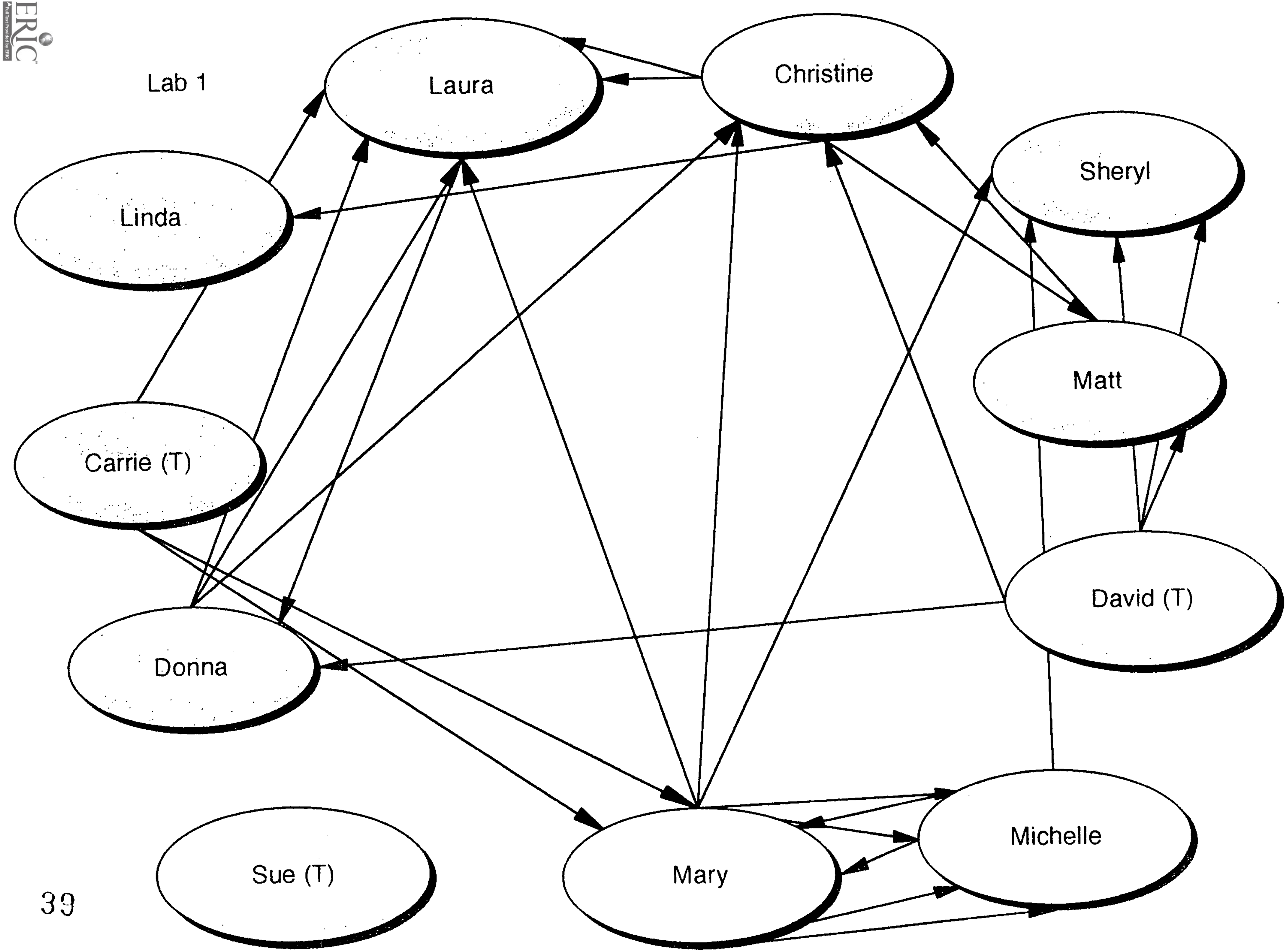
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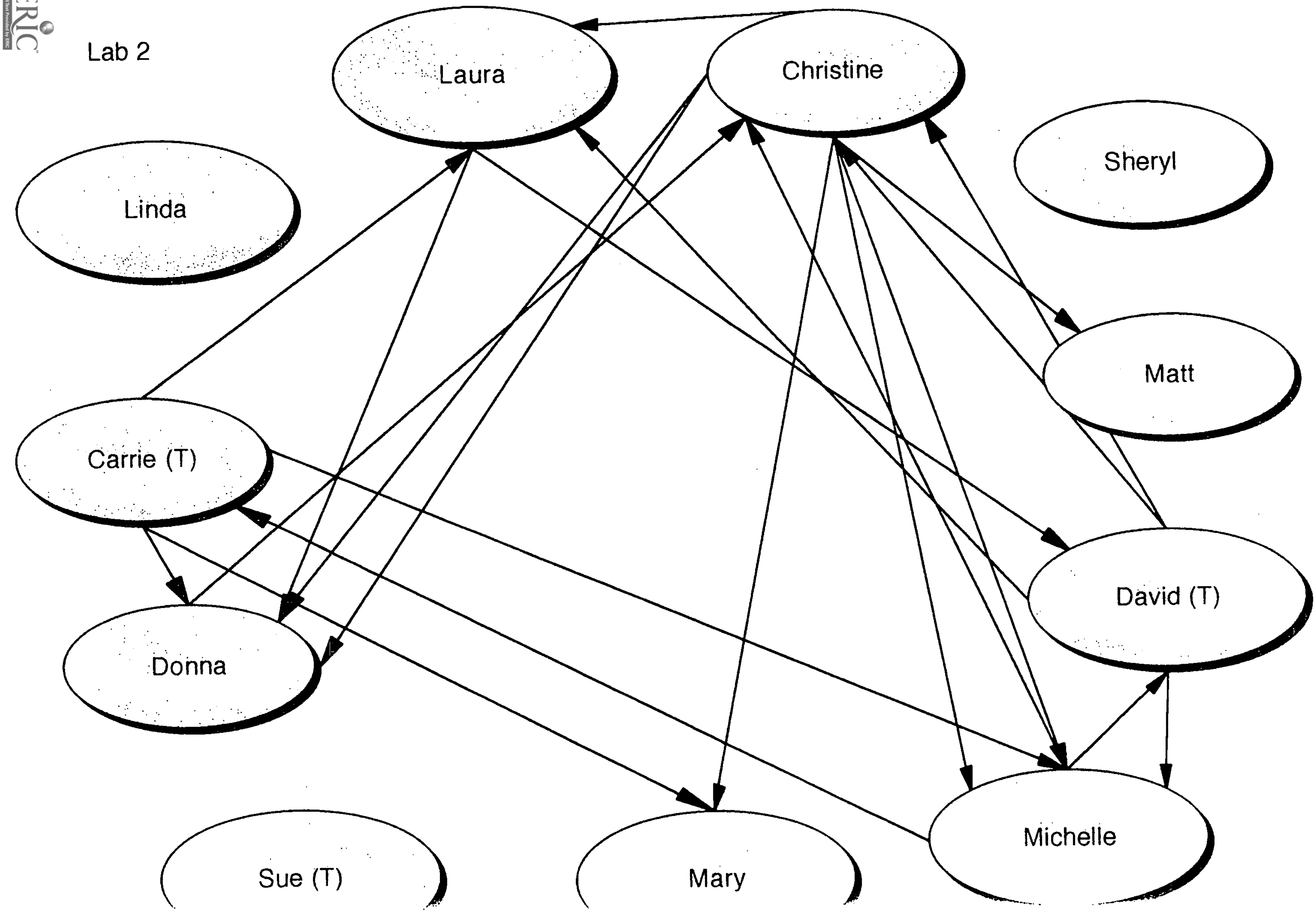
Christine
Linda
Sheryl
Matt
Carrie (T)
David (T)
Donna
Sue (T)
Mary
Michelle

Lab 2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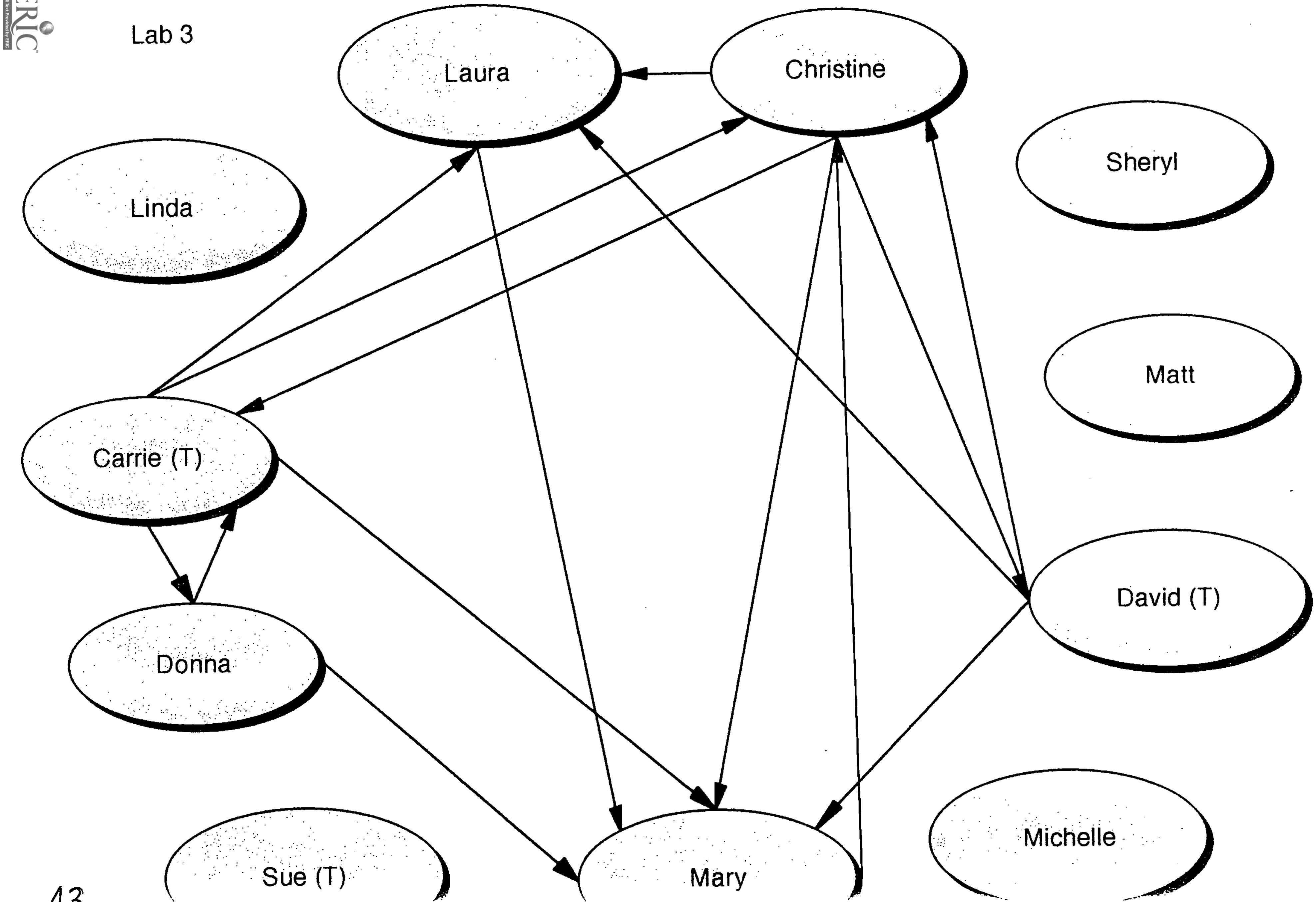
David (T)
Donna
Michelle
Sue (T)
Mary

Lab 3


Laura
Christine
Linda
Sheryl
Matt
Carrie (T)
Donna
David (T)
Sue (T)
Mary
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